Test Procedures and Acceptance Criteria for Plastic Encapsulated Microcircuits in Space and Military Applications

Presented by

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Overview

- Background
- Project Objectives
- Project Results to Date
- Summary

Background

- Availability of Mil Grade semiconductors is limited
- Use of plastic encapsulated microelectronics (PEMs) is increasing for all space and military applications
- COTS parts in low volume are only available through distribution
- PEMs require screening and testing to verify that parts have integrity for military environments
  - lot by lot
  - Vendor specific issues
  - Application considerations
- Procedures for ensuring quality and integrity of COTS/PEMs components needs to developed and established

Issues for Utilizing PEMs

- Consistency and control over manufacturing processes
- Product life cycles
- Domestic sources: most packaging is done overseas
- Packaging
  - Die shrink
  - Interconnect format (BGA, fine pitch leads, lead counts)
- Environmental durability
  - Radiation hardness
  - Temperature cycling
  - Humidity
  - Vibration

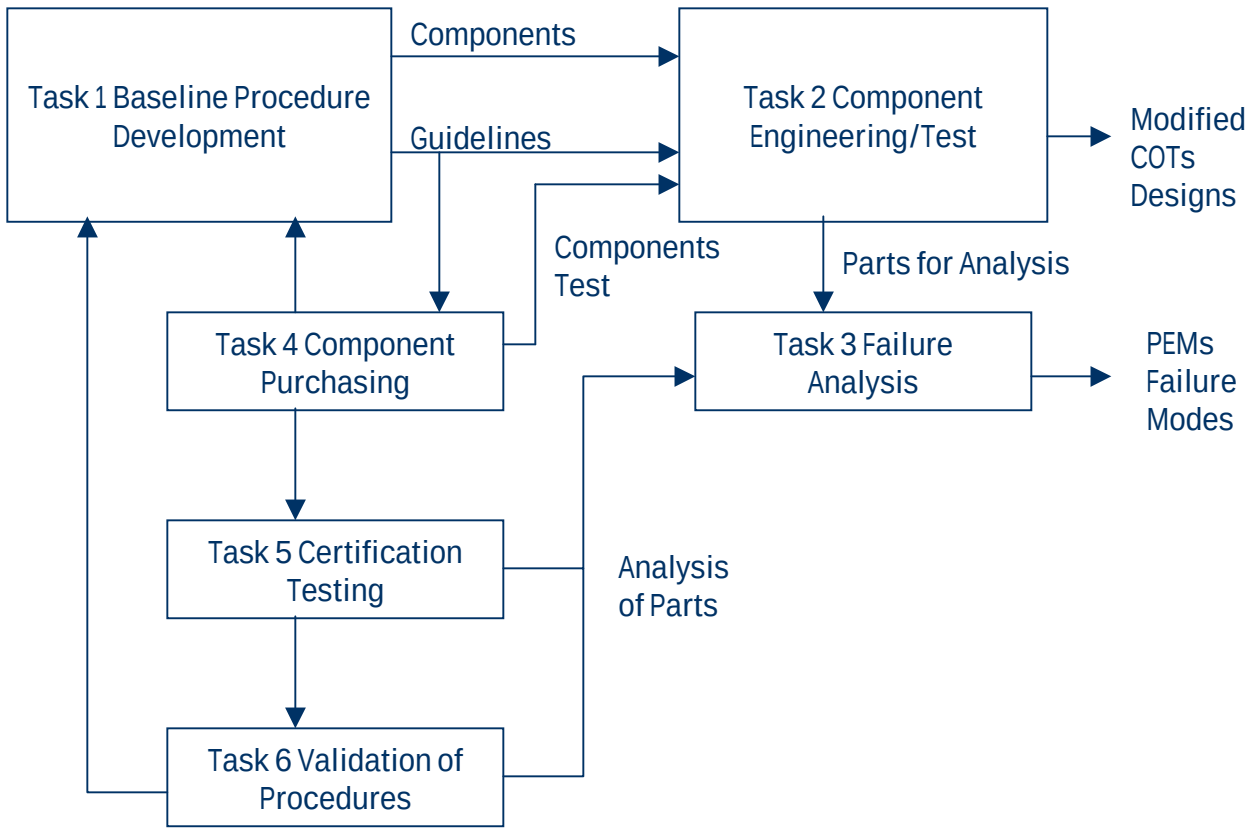
Issues for Utilizing PEMs (cont'd)

- Certification procedures such as Mil std 883 may be overkill or don't apply
- Certification and upscreening not fully developed
  - Procedures
  - Acceptance criteria
- Life tests from commercial suppliers are set up to ensure yields

Project Objectives

- Develop procedures and acceptance criteria for using PEMs in military and space applications
- Determine procedures and requirements for procuring quality PEMs via distribution
- Develop unique tests that will enable components to be certified for use in specific environments
- Establish a data base and data transfer mechanism on PEMs performance/reliability

PROGRAM TASK FLOW



Development of Procedures

- Baseline procedures have been drafted and reviewed (TRW)
- AMT will procure components following procedures and test requirements
- Data and information from procurement and testing will be used to develop procedures and criteria

Formulation of Procedures

- Parts for military and space are primarily available from distribution
- Development of procedures is focusing on best practices for procuring from distribution
- Tests and screening will
  - Identify visual defects prior to evaluation
  - 100 % screen to identify infant mortality testing
  - Lot screening to ensure integrity of lots and sorting of vendors
- Certification/Qualification
  - Determine overall adequacy of parts on a vendor by vendor basis and part by part basis
  - Demonstrate adequacy of PEMs for space/military applications

Outline of Procedures

PROCEDURE ITEMS	DESCRIPTION
◆ PACKAGE AND STORAGE	SPECIFIES PACKAGE STORAGE AND HANDLING REQUIREMENTS
◆ MATERIALS	DEFINE DETAILS OF DIE AND PACKAGE MATERIALS
◆ SCREENING	DESCRIBES LOT TESTING REQUIRED BY SUPPLIER
◆ ADDITIONAL SCREENS AND TESTS	DEFINES SCREENING/TESTS PERTAING TO SPECIALIZED COMPONENTS SUCH AS BGA, CGA
◆ QUALIFICATION	SPECIFIES A BROAD RANGE OF TESTING COVERED BY MIL STD 883 AND JEDEC WHICH PERTAIN TO PEMs
◆ DPA	DEFINES DESTRUCTIVE EXAMINATIONS TO BE PERFORMED ON COMPONENTS
◆ PREPARATION FOR USE	DEFINES PREPARATION PROCEDURES PRIOR TO BOARD MOUNTING

Packaging Considerations

Table 2: Packaging Style Considerations

Package Style	Board Attachment	Failure Suseptibility	Lead Count	Current/Future Usage
Dual in-line package (DIP)	Pin through hole (PTH)	Temperature, Humidity, Popcorning	Limited to low value	will be phased out
Standard Outline Package (SOP)	Surface Mount Technology (SMT)	Temperature cycling, Popcorning	Limited to low value	will be used for low lead count applications
Thin SOP (TSOP)	Surface Mount Technology (SMT)	Same as SOP with higher level of suseptibility	Same as SOP	Low profile is very attractive
Quad Flat Pack (QFP)	Surface Mount Technology (SMT)	Humidity, Popcorning	Up to 300	high lead counts are impractical due to footprint
Ball Grid Array (BGA)	Surface Mount Technology(SMT)	Themperature cycling, Popcorning, Humidity	very high > 1000	Rapidly becoming industry standard

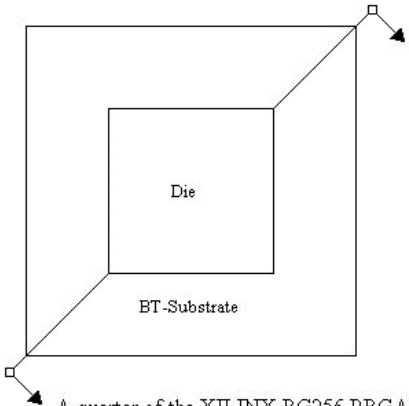
Components for PEMs Evaluation

- BGA packaging is expected to dominate the semiconductor industry in the near term
- ASICs and microprocessors are high value added components
- Gate arrays and other logic devices are of highest interest to the aerospace industry

Failure Analysis

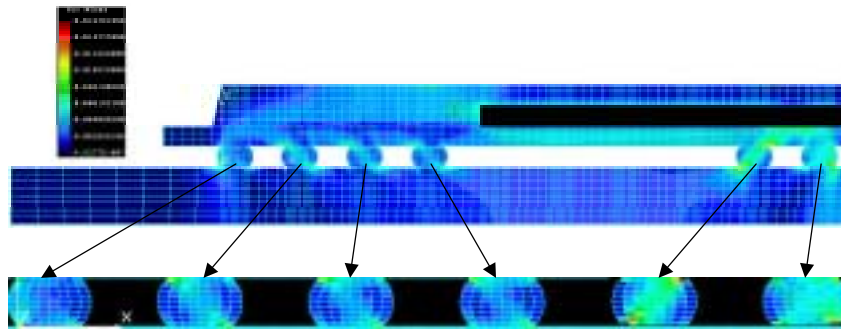
- AMT will establish a physics based approach for assessing failures and determining the causes
- Failure modes will be investigated
- Potential failure modes and thresholds will be determined
- Methods of investigating failure will be established
- Methods of correcting failures will be identified and implemented

Physics Based Reliability Analysis

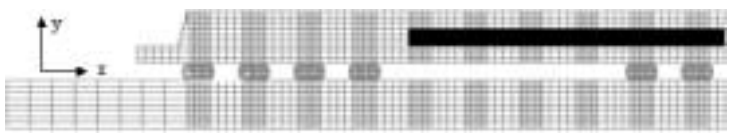


A quarter of the XILINX BG256 PBGA package was modeled diagonally as shown with arrows

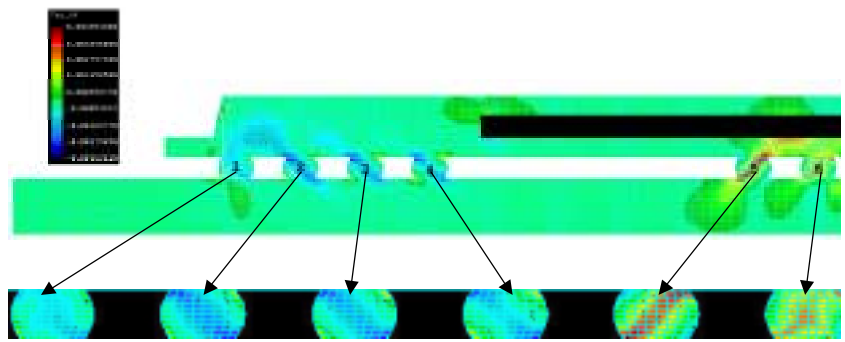
BGA Component



Von Mises Stresses



2D Plane Stress Model

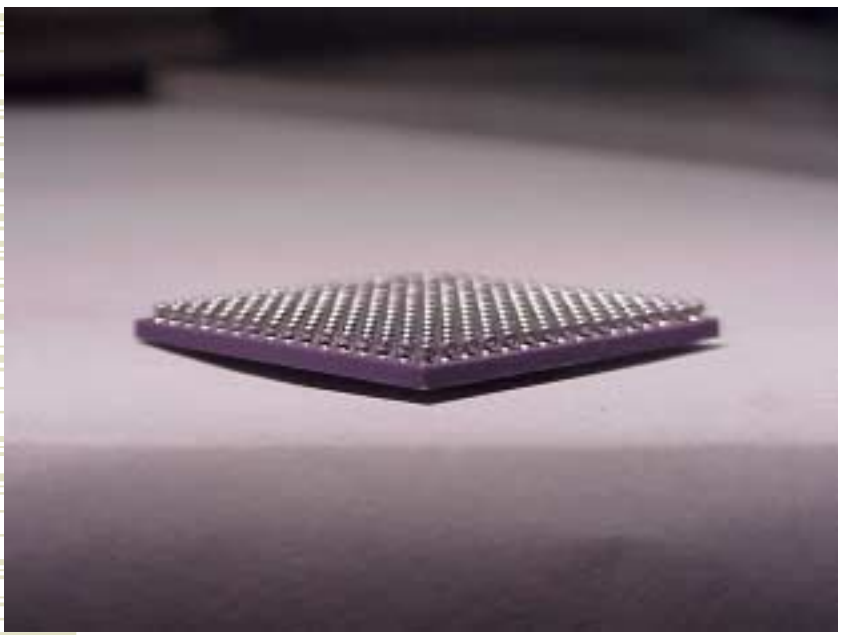


Shear Stresses

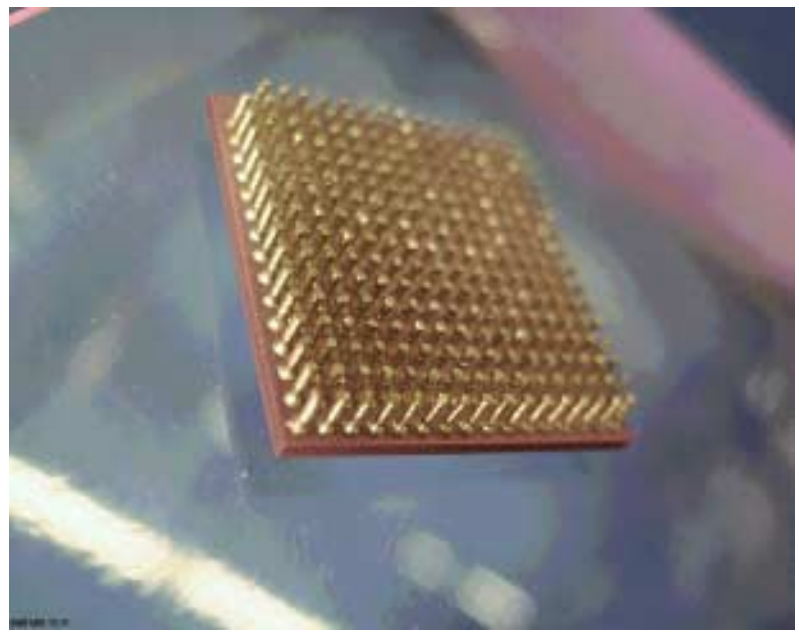
Ruggedization of COTS

- Compliant leads
- Coatings for die – WAASP
- High temperature BGA substrates
- Thermal leads for BGAs

Typical BGA and CGA



Motorola PowerPC
Ball Grid Array



Motorola PowerPC
Column Grid Array

Verification Test Plan

Component	Xilinx XQV 100-4-BG256	Xilinx XCV 100-BG256	Xilinx XIV 100-BG256	Linear Tech LTC 1419
Package	PBGA	PBGA	PBGA	TSOP
Sequence 1	5	5	5	5
Physical Dimensions	5	5	5	5
1a: Solderability	2	2	2	2
1b: Resistance to Solvents	3	3	3	3
Sequence 2	15	15	15	15
Thermal Shock	15	15	15	15
Temp Cycle	15	15	15	15
Acoustic Microscopy	15	15	15	15
X-ray	15	15	15	15
Electric Testing	15	15	15	15
Sequence 3	15	15	15	15
Precondition Bake	15	15	15	15
3a: HAST	8	8	8	8
3b: 85/85	7	7	7	7
Acoustic Microscopy	15	15	15	15
Electric Testing	15	15	15	15
Sequence 4	15	15	15	15
Moisture	15	15	15	15
4a: Salt Atmosphere	5	5	5	5
4b: Autoclave	10	10	10	10
Electric Testing	15	15	15	15
Sequence 5	10	10	10	10
5a: Cross section	5	5	5	5
5b: Decaping	5	5	5	5
Acoustic Microscopy	10	10	10	10
X-ray	10	10	10	10
Sequence 6	11	11	11	11
Radiation	11	11	11	11
Acoustic Microscopy	11	11	11	11
Electric Testing	11	11	11	11

Development of Testing and Failure Analysis Capabilities

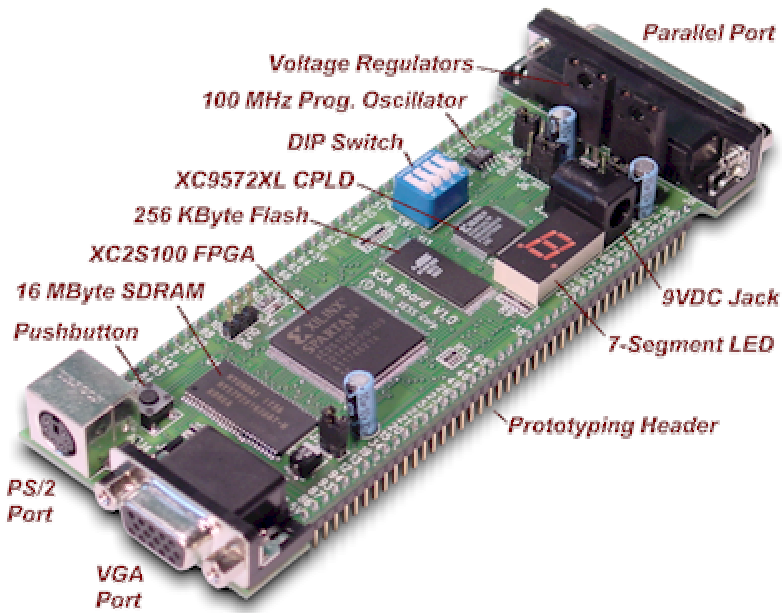
- COSMOS Finite Element Analysis for BGAs
- Functional electrical testing
- Temperature humidity testing
- Autoclave
- T-M vacuum oven
- Braebender moisture analyzer
- Etec scanning electron microscope
- Buehler polishing/cross sectioning equipment

Functional Testing of Components

FPGA Components

FPGA Socket Interface

Functional Test Board



- Functional board for Xylinx FPGA
- Interfaces to socketed test board
- Enables programming to a PC
- Used for pre and post test characterization

Temperature Humidity Chamber

Agency Approvals:

C-UL AND UL-508 LISTED

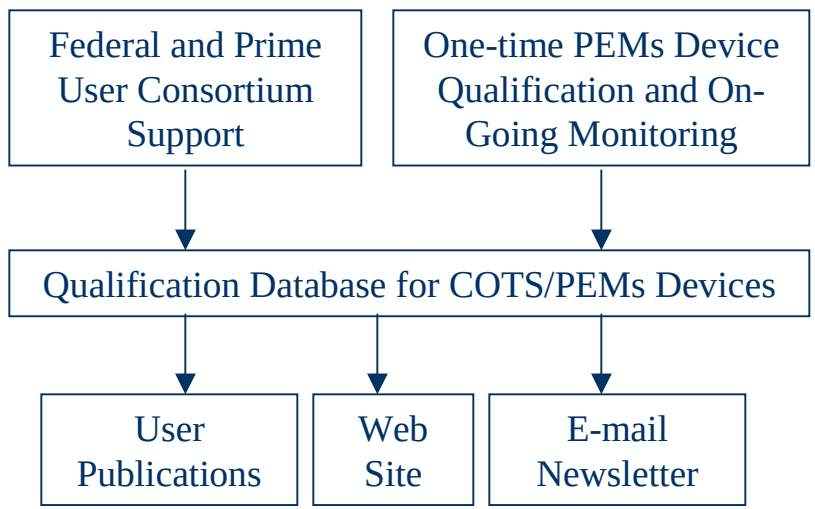
- CSZ Temperature/Humidity Chamber
- 8 cu. Ft. of working space
- LN2 cold assist/hot temperature boost
- 15 deg C/s ramp rate
- -65 C to +150 C temperature range
- 0-98 % relative humidity

Autoclave

- Autoclave testing capability
- Vacuum to 200 psi pressure
- Temperature/humidity controlled environment
- 12 inch x 24 inch working space

PEMs Qualification Database for Space Applications

- Based on PEMs purchased from the manufacturers distributor
  - Quality control/processing data, for military and space users, is generally unavailable from PEM manufacturers
  - PEMs manufacturers do not see the need to be subjected to qualification by military and space users
- Database of Qualified Parts and Qualification Test Results will be openly made available as an aid to proliferation of COTS/PEMs use for space
  - AMT would maintain Web site and e-mail newsletter to member user community
  - Web site could be mirrored at DoD or NASA Web sites
  - DoD, NASA, Prime Consortium funding for one-time qualification of PEMs for development of catalog of qualified PEMs parts



Summary

- This SBIR project is an important part of ensuring high quality microelectronics for future military applications
- Procedures that are established will provide AMT with critical capability to supply high reliability semiconductors
- Unique tests that simulate actual conditions for space and military environments will provide users with critical information to reduce risk
- Data base and data sharing mechanisms will provide key information that will enable proper utilization of PEMs devices